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EVALUATION OF COLIFORM CONTRIBUTION BY PLEASURE BOATS

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Lear, Marks and Schmincke
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Middle Atlantic Region

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I. INTRODUCTION

Much concern is voiced over the pollution potential of boating activity, but little definitive data exists concerning the extent of human fecal pollution contributed from pleasure boats.

A scheduled rendezvous of the Annapolis Yacht Club on July 22-26, 1966, at the Miles River Yacht Club located on Long-haul Creek, adjacent to the Town of St. Michaels, Talbot County, Maryland, afforded the Chesapeake Field Station an opportunity to conduct a study under field conditions to determine the relationship of coliform densities to pleasure boat count in the Area. Temporary bacteriological laboratory facilities were set up in a nearby motel to determine coliform and fecal streptococci population densities, and sampling stations in the vicinity of the Yacht Club were established (Figure 1). The sampling program began at 12:00 Friday, July 22, 1966.

II. MATERIAL AND METHODS

Coliform confirmed population estimates were made by the 5-tube, 3-dilution MPN method. Difco lauryl tryptose broth was used for presumptive media, and Difco Brilliant Green lactose bile broth, two per cent, was used for confirmation of coliforms.

Fecal streptococci were estimated with the same MPN technique, with presumptive Difco azide broth and confirmed in BBL ethyl violet azide broth.

Samples were gathered from a 14-foot aluminum jon boat by hand dipping into sterile 6-ounce prescription bottles. Immediately after collection, samples were returned to shore and inoculated into the media, using the back end of a station wagon for working area. Consequently, samples were inoculated approximately 15 minutes after collection.

Incubation of tubes was at 35° C. in bacteriological incubators established in the nearby motel, and transfers from positive tubes were accomplished in the makeshift laboratory using a portable propane torch to flame the bacteriological loops.

III. THE INVESTIGATION

Preliminary to sampling, a reconnaissance was made of Longhaul Creek (Figure 1). In addition to the Miles River Yacht Club facility, four homes were located along the creek, and the adjacent land was cultivated farmland. One home, approximately 150 yards upstream from Station D, had two dozen or so domestic ducks penned on the bank of the creek. An occupied house trailer was noted on the west shore of the creek.

A count of the number of boats in the Area was made during the study. All boats were counted during the reconnaissance, but during the study only occupied boats with toilet facilities were counted. The initial count made at 11:30 Friday, July 22, showed 17 small boats with no toilets and 32 unoccupied boats with toilets. The number of small boats without toilets remained

essentially the same throughout the study, except for a few satellite dinghies with the transient craft.

Observation of activities at the Miles River Yacht Club indicated that, although it is in rural surroundings, the Club is constantly a focal point for various activities. The Club has a swimming pool and, apparently, a swimming team. During the study, two separate crab feasts were catered on the veranda of the Club House. One of these was rather small, restricted to the Annapolis rendezvous group only. The other was sponsored by a local organization for the general public and was well attended. At the outset of the study, several boats with New Jersey registration were noted, apparently the departing vestiges of a smaller rendezvous or cruise of a New Jersey club activity. The rendezvous during the study period, however, far exceeded the normal weekday routine activity.

No precipitation occurred during the study, and weather conditions could best be described as a portion of a drought cycle.

Samples were collected from four stations (see Figure 1) three times daily, at approximately 0800, 1400, and 2000 hours. Station A was located by the red nun buoy No. 12 in the Miles River, approximately 500 yards from the mouth of the Creek. This control station was presumed to indicate the quality of water inflow into the Creek on flooding tide.

Station B was located at the mouth of Longhaul Creek, approximately 30 yards off the offshore end of the docking area, and approximately in mid-stream. All boats were docked or moored inside the Creek with respect to this station.

Station C was located in mid-stream at the opposite end of the dock facilities, at approximately the point where the Creek bifurcates. This station was often in the area of anchored boats.

Station D was made at the entrance of the southwest branch of Longhaul Creek. This was upstream from all yacht club boating activities, yet downstream from three homes, including the one with ducks penned on the Creek bank.

IV. RESULTS

Data resulting from this study are shown in Table 1. Tides were estimated from the U. S. Coast and Geodetic Survey Tide Tables, 1966, corrected for St. Michaels, Miles River.

Two things should be noted from the tabular presentation: (1) fecal streptococci were nearly always so low in density as to be immeasurable during the study, at all stations; (2) no apparent relationship seems to exist between tidal stage and bacterial population density.

Coliform bacteria and number of boats are shown graphically in Figures 2 through 5. Station A, Figure 2, in the Miles River, showed a low incidence of coliforms throughout the study.

Station B, Figure 3, at the mouth of the Creek, showed a low incidence of coliforms before the boats arrived, then a general increase to 200-500 coliforms/100 ml. Persistence of these counts after the departure of the boats is evident.

Figure 4 shows Station C, off the marina in the Creek. An anomalous figure of 2,400 coliforms/100 ml is shown, before the boats arrived. This study assumes the integrity of the shore facilities, and a "rested" condition from previous boats, which may not be entirely sound. However, two of the initial bacterial determinations showed counts less than 20, and the same general increase with the arrival of the boats as found at the other two stations in the Creek.

The station farthest upstream, Station D, is shown in Figure 5, and again the same trend of a coliform increase with the arrival of the boats and persistence after the departure is apparent.

V. DISCUSSION

These data collectively indicate a slight increase and persistence of coliforms with the congregation of pleasure yachts. An estimation of the degree of significance of yacht contribution was attempted by analyzing the coliform counts with respect to increased number of boats. The data from the initiation of the study to the point where the maximum number of boats with toilets (85) occurred, were analyzed with simple regression. This does

not take into account any persistence of bacteria after the departures, and assumes also that only boats contributed coliforms.

Logarithms of the number of coliforms, rather than arithmetic figures, were used because the logarithms of coliform MPN's have been shown to be normally distributed, while the raw data are generally skewed. For these analyses, a zero count of boats was assumed to be one, and coliform densities less than 20, the lower limit of determination with the procedure used, assumed to be 2 coliforms/100 ml. These assumptions tend to make errors on the conservative side.

Station A, Figure 6, shows no relationship between number of boats and coliforms, as should be expected from the control station.

Station B, Figure 7, shows the regression between the increase of boats and the logarithm of coliform MPN. The slope of this line showed a significant fit at the five per cent level with the "t" test. This slope, b = 0.0225, indicated an increment of approximately 1 coliform per 100 ml water for each boat (antilog 0.0225 = 1.053).

Station C, Figure 8, showed no significant regression when all data were considered. If the 2,400 coliform MPN, anomalously found before the boats arrived, were disregarded, a good regression was found, b = 0.01316, t = 3.26, d.f. = 4. This slope, shown as the dotted line on Figure 8, agrees fairly close with Stations B and D.

Station D, Figure 9, indicates an increase similar to that at the other Creek stations, b = 0.0097, but the "t" test for goodness of fit fell just short of significance at the five per cent level.

These data collectively indicate the order of magnitude of the increase of pollution by boats, under the conditions of this study. The persistence of bacterial counts is not considered, nor is the duration of stay of boats, in this case a little over 24 hours, and these factors should be considered in future study designs.

Boundary conditions undoubtedly affect values, due to mixing and dilution. The estimated size of Longhaul Creek, taken from a U. S. Geological Survey topographic map, was 1,800,000 square feet or 41.3 acres. With depths from the appropriate U. S. Coast and Geodetic Survey chart, an approximate volume of 18,266,000 cubic feet or 136.6 million gallons was calculated. With a tidal range of 1.2 feet, or 2,160,000 cubic feet, or 16.1 million gallons, this would indicate a 12 per cent augmentation on the average flood tide. No stratification of termperature with depth was found at any station during this study, as measured with an electronic thermometer. Exchange or excursion values were not obtained from these data, but this Creek would seem to be relatively homogeneous, with respect to the sampling program undertaken.

Another factor to be considered is marina habits; i.e., the degree to which on-board facilities are used with respect to the facilities available on shoreside. This factor would probably vary with each study situation.

A second study was contemplated by the Chesapeake Field Station staff in 1966 at the Rose Haven Marina, Herring Bay, Anne Arundel County, Maryland. Preliminary to an extensive study, the waters were sampled to establish background bacteriological levels under conditions of minimum boat occupation. These results are shown in Table 2.

As can be noted from Table 2, the degree of change in bacterial level anticipated from approximately 400 boats, an estimated increase of 400 coliforms/100 ml/boat/day, could probably not have been detected because of the pollution contribution from one shore-based septic tank system.

These observations indicate that the relative significance of pleasure boats contaminating the waters is much less than contributions from nearby domiciles, served with individual septic tank systems, and under conditions of these studies.

The results of this study are illuminating, but not definitive.

Further elucidation of the magnitude of bacterial contribution from pleasure boats can be accomplished in field designs which incorporate:

1. More extended observations of the background bacterial densities in "rested" water prior to occupation by boats.

2. Determination of coliform, fecal coliform, and fecal streptococci, for possible interpretation of human and animal contribution, and as an indicator of recent, as opposed to remote, pollution.

3. Observations extending to include the subsequent decline of bacterial densities, which would depend on local boundary conditions, duration of boat stay, etc.

4. If possible, detailed studies of the hydrology that would further quantitate the effects of small boats per unit volume of water should be concurrently executed.

5. Studies conducted in different aquatic environments, to minimize local effects, are necessary to quantitate the cause and effect relationships.

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2. Hopkins, T. C., and Sanderson, A. E., Report Number Two on coliform and E. coli bacteria counts at a major Chesapeake Bay boating-bathing site during the Independence Day holiday period 1965. Mimeographed report. Maryland Department of Water Resources, Water Quality Division.

Table 1

Bacterial Counts in Longhaul Creek, Maryland
During a Yacht Rendezvous

	Station	Date/Time	Coliform	Fecal Streptococci	Occupied Boats With Toilets	Tide
A.	Red nun "12" in Miles River off Longhaul Creek. (Control Station)	22 - 1145	<20	20	0	Ebbing
		1335	20	<20	0	Ebbing
		1650	<20	18	10	Flooding
		1958	45	<20	23	Flooding
		23 - 0755	<20	<20	29	Slack Flood
		1345	<20	<20	64	Ebbing
		1952	<20	<20	84	Flooding
		24 - 0802	18	<20	85	Flooding
		1345	<20	20	10	Ebbing
		1948	<20	20	0	Flooding
		25 - 0813	<20	<20	0	Flooding
		1320	<20	<20	0	Ebbing
		1957	20	<20	2	Flooding
		26 - 0807	45	<20	2	Slack Ebb
		1344	<20	<20	0	Ebbing
		1648	45	20	0	Ebbing
B.	Longhaul Creek mouth. Seaward of moorings.	22 - 1340	<20	<20	0	Ebbing
		1702	<20	<20	10	Flooding
		2005	20	<20	23	Flooding
		23 - 0801	220	<20	29	Slack Flood
		1353	78	<20	64	Ebbing
		1956	330	20	84	Flooding
		24 - 0805	170	20	85	Flooding
		1349	490	<20	10	Ebbing
		1955	170	<20	0	Flooding
		25 - 0818	490	<20	0	Flooding
		1324	20	<20	0	Ebbing
		2003	220	<20	2	Flooding
		26 - 0812	110	<20	2	Slack Ebb
		1348	490	20	0	Ebbing
		1653	110	<20	0	Ebbing
C.	Longhaul Creek. Directly off docks and among moored boats.	22 - 1343	2,400	<20	0	Ebbing
		1704	20	18	10	Flooding
		2008	170	<20	23	Flooding
		23 - 0803	45	<20	29	Slack Flood
		1356	230	<20	64	Ebbing
		1959	330	<20	84	Flooding

Table 1 (Continued)

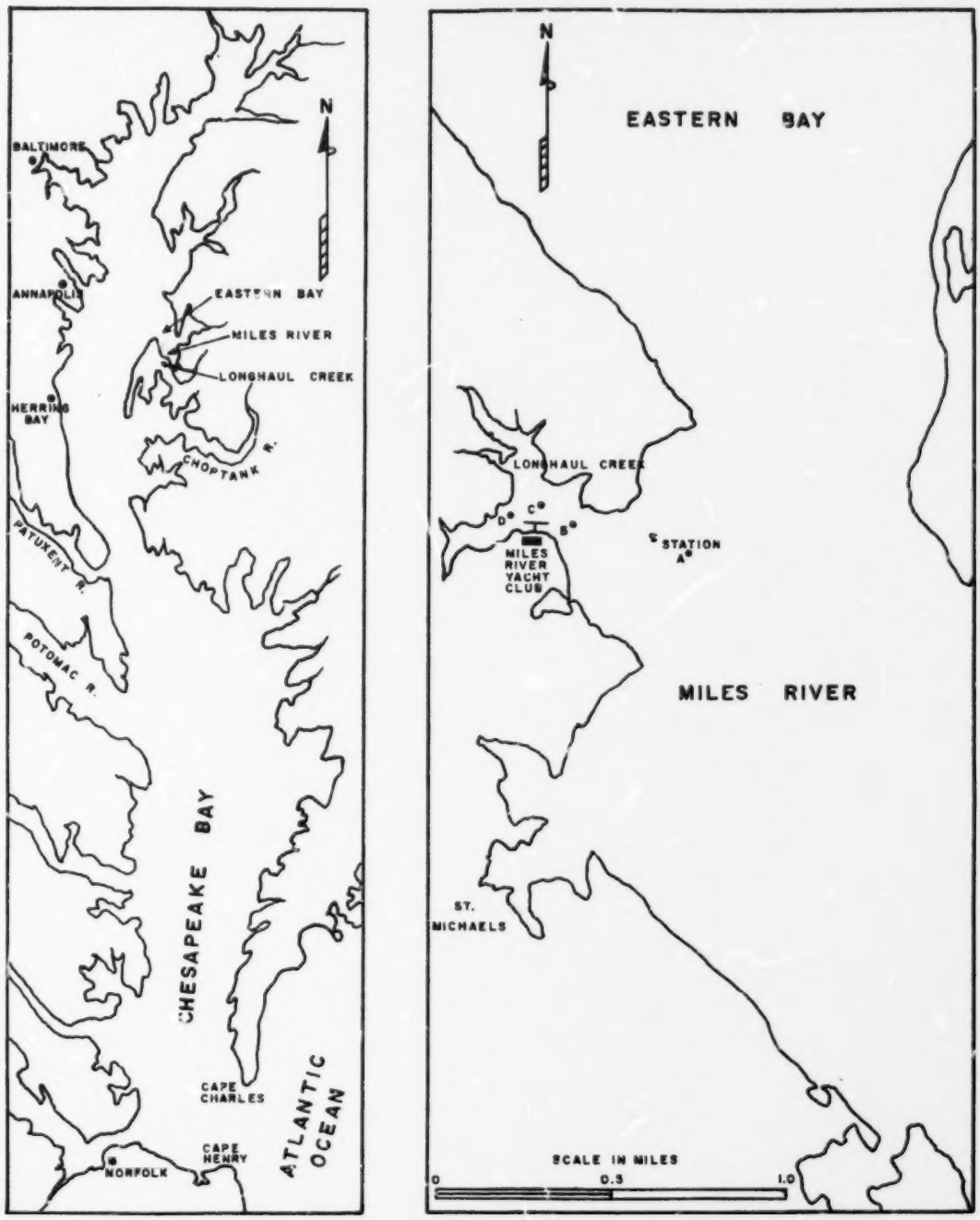
Station	Date/Time	Coliform	Fecal Streptococci	Occupied Boats with Toilets	Tide
C. (Continued)	24 - 0808	330	<20	85	Flooding
	1351	490	<20	10	Ebbing
	1958	490	45	0	Flooding
	25 - 0820	170	20	0	Flooding
	1326	330	<20	0	Ebbing
	2005	790	<20	2	Flooding
	26 - 0815	110	52	2	Slack Ebb
	1352	490	<20	0	Ebbing
	1656	790	20	0	Ebbing
D. Longhaul Creek. Upstream from all boats. In mouth of south branch.	22 - 1135	20	<20	0	Ebbing
	1344	20	<20	0	Ebbing
	1707	330	<20	10	Flooding
	2008	140	<20	23	Flooding
	23 - 0805	45	<20	29	Slack Flood
	1358	490	<20	64	Ebbing
	2001	130	<20	84	Flooding
	24 - 0811	330	20	85	Flooding
	1400	110	<20	10	Ebbing
	2001	5,400	45	0	Flooding
	25 - 0822	790	20	0	Flooding
	1329	330	<20	0	Ebbing
	2007	700	20	2	Flooding
	26 - 0817	68	<20	2	Slack Ebb
	1354	790	<20	0	Ebbing
	1659	790	<20	0	Ebbing

Table 2

Bacterial Population Density Estimations
Rose Haven Yacht Club, Herring Bay, Anne Arundel County, Maryland

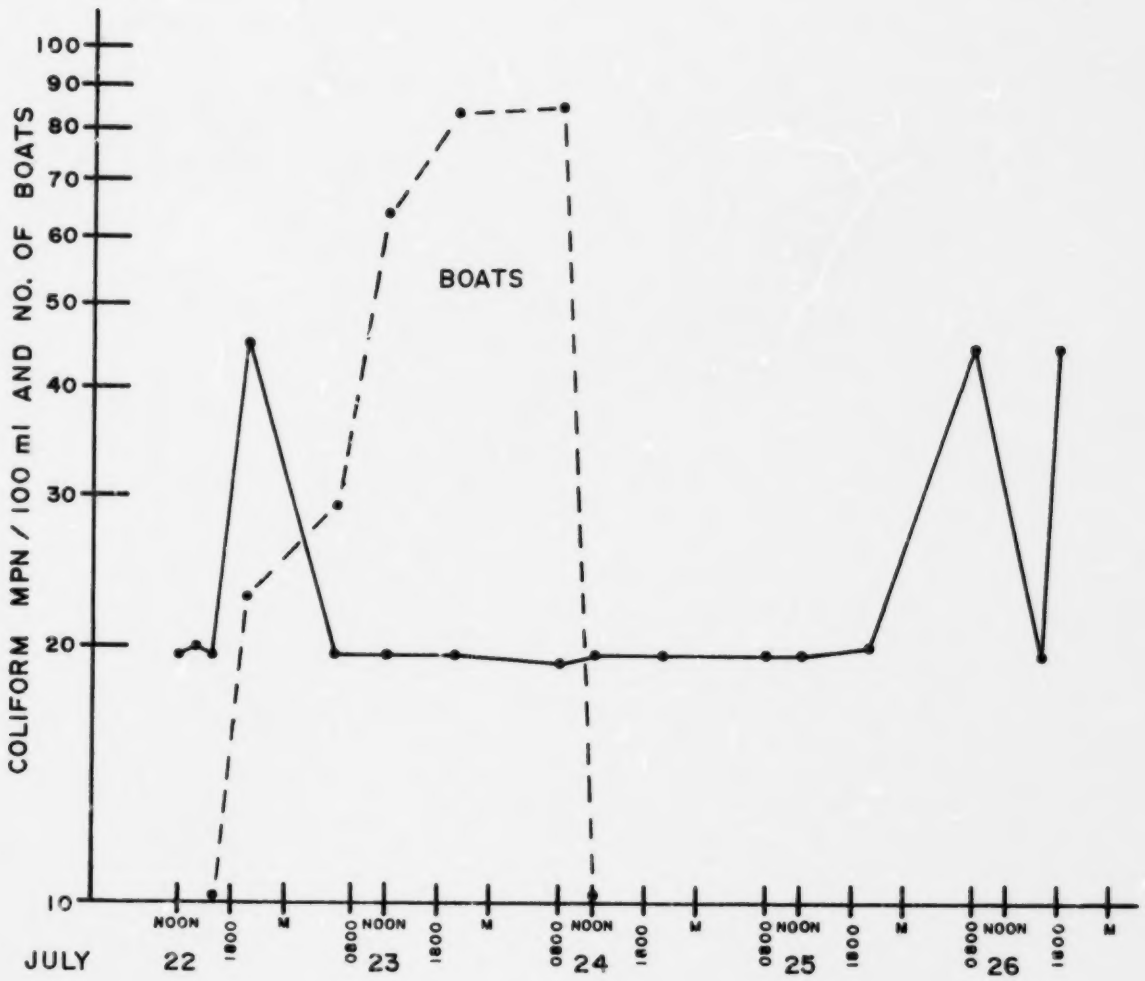
104 Boats, 150 Empty Slips
August 29, 1966

Location	Coliform MPN/100 ml	Fecal Coliform MPN/100 ml
1. Pier, farthest upstream	170	50
2. J-Dock, upstream from clubhouse	2,400	50
3. Apparent septic discharge behind clubhouse	>160,900	27,800
4. Main dock behind clubhouse	5,420	50
5. Channel into harbor	700	100



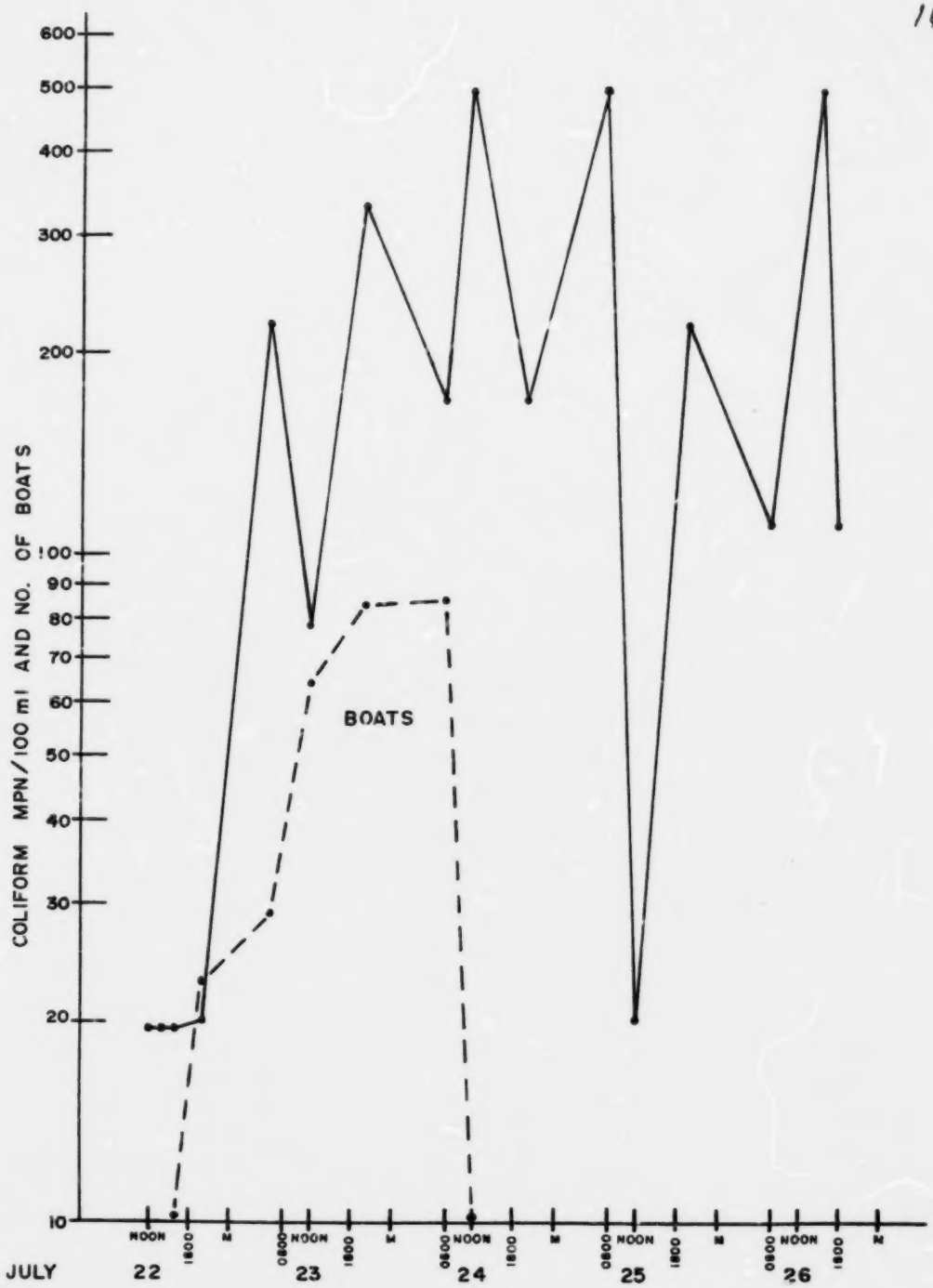
LOCATION MAP OF STUDY AREA

FIGURE 1



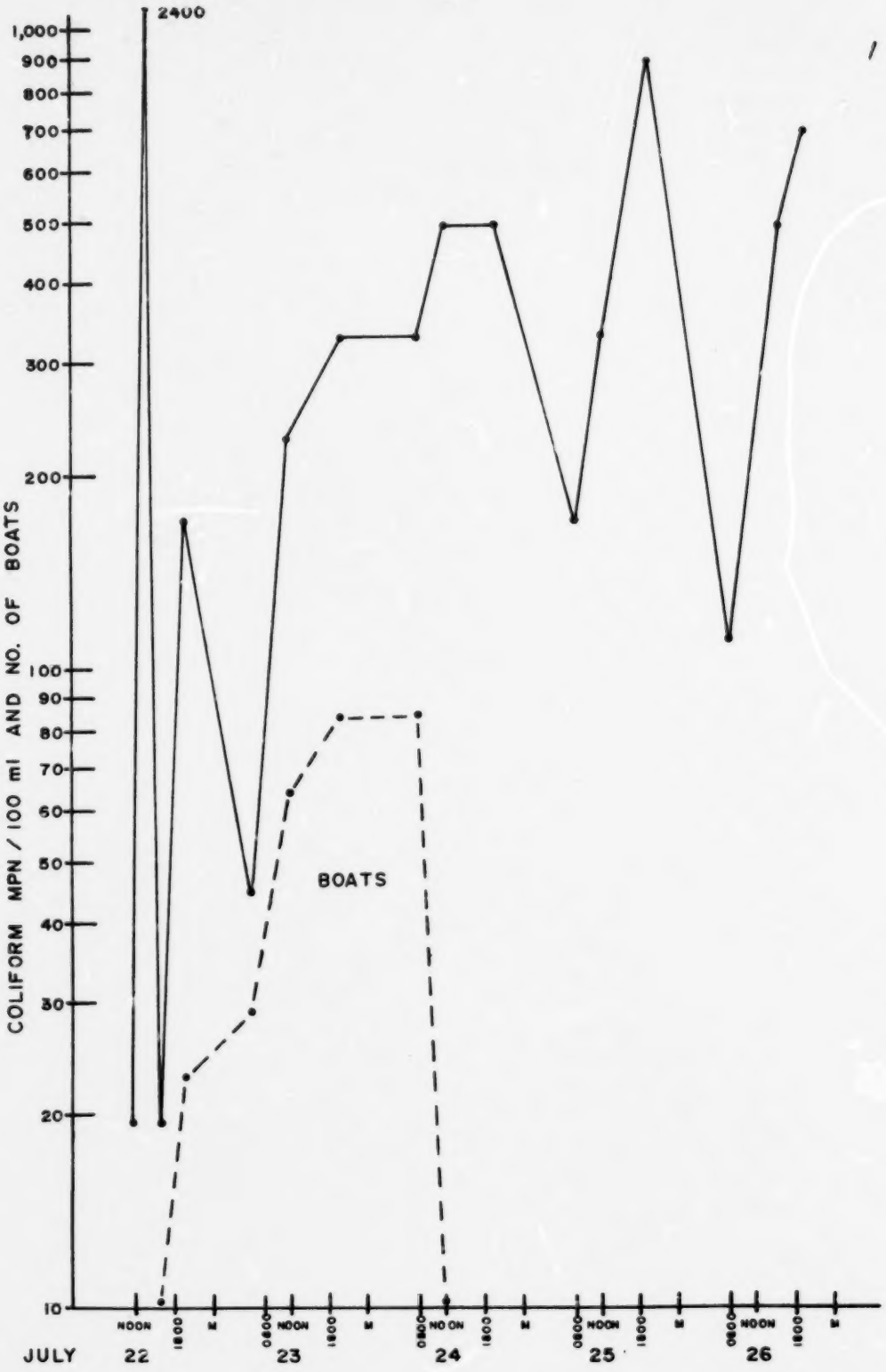
COLIFORM POPULATIONS AND NUMBER OF BOATS
STATION A

FIGURE 2



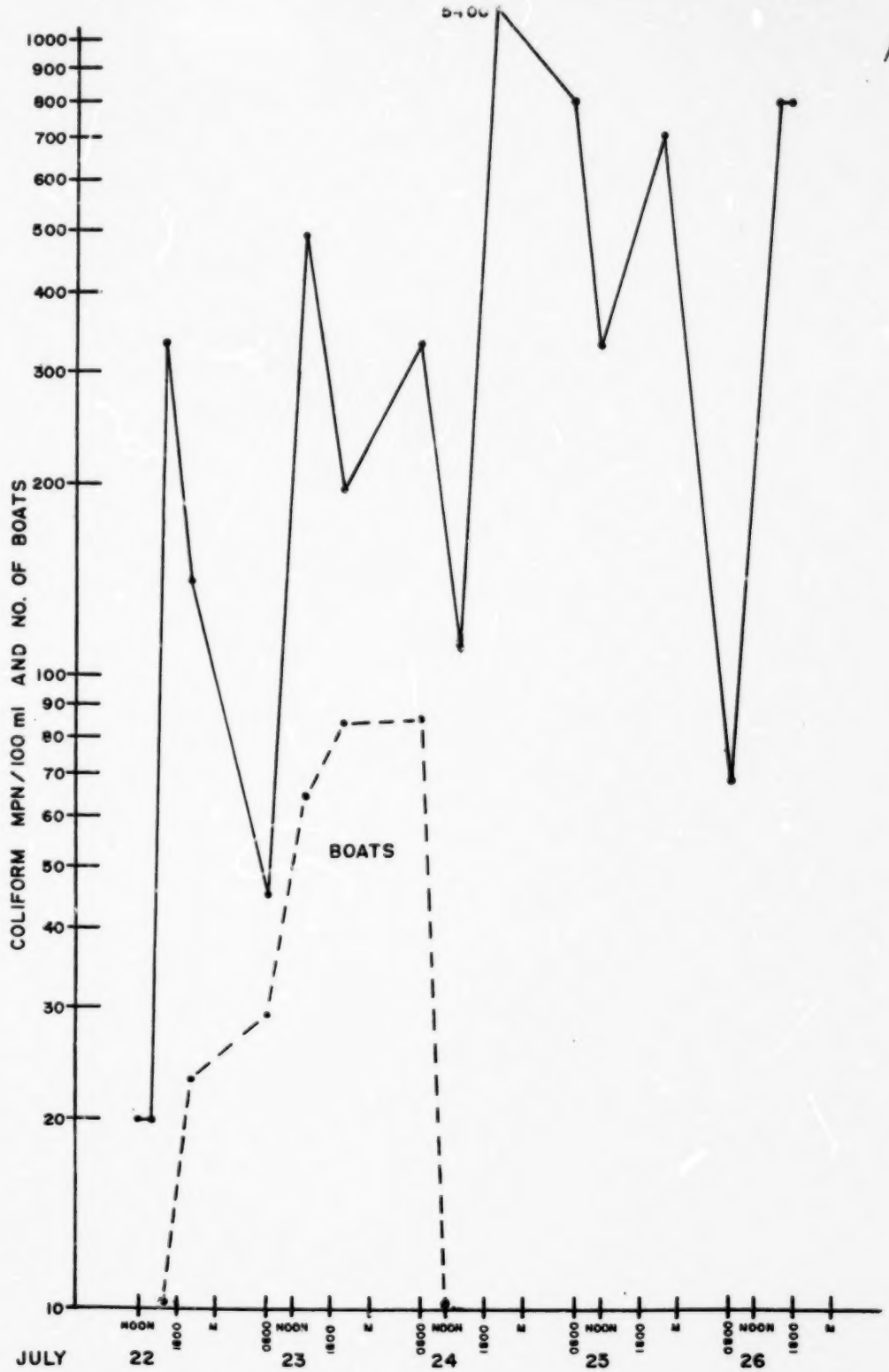
COLIFORM POPULATIONS AND NUMBER OF BOATS
STATION B

FIGURE 3



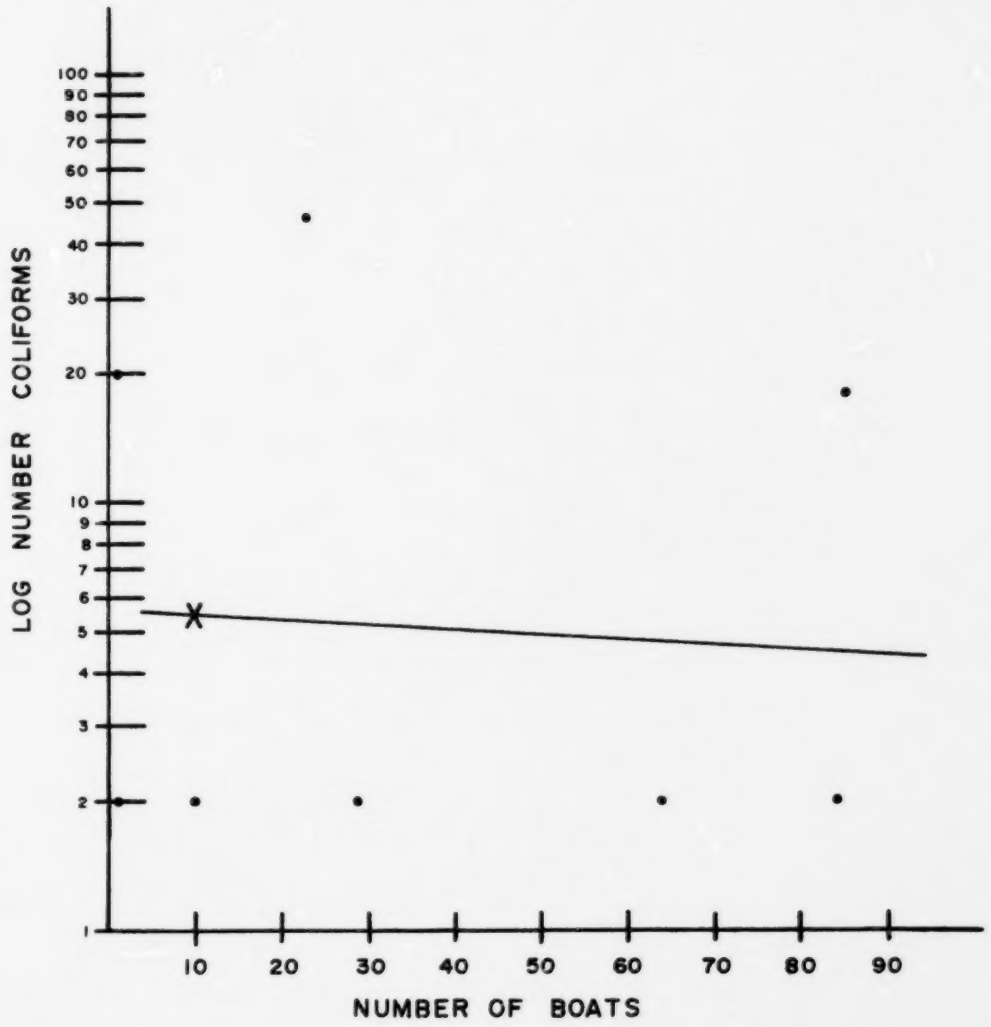
COLIFORM POPULATIONS AND NUMBER OF BOATS
STATION C

FIGURE 4



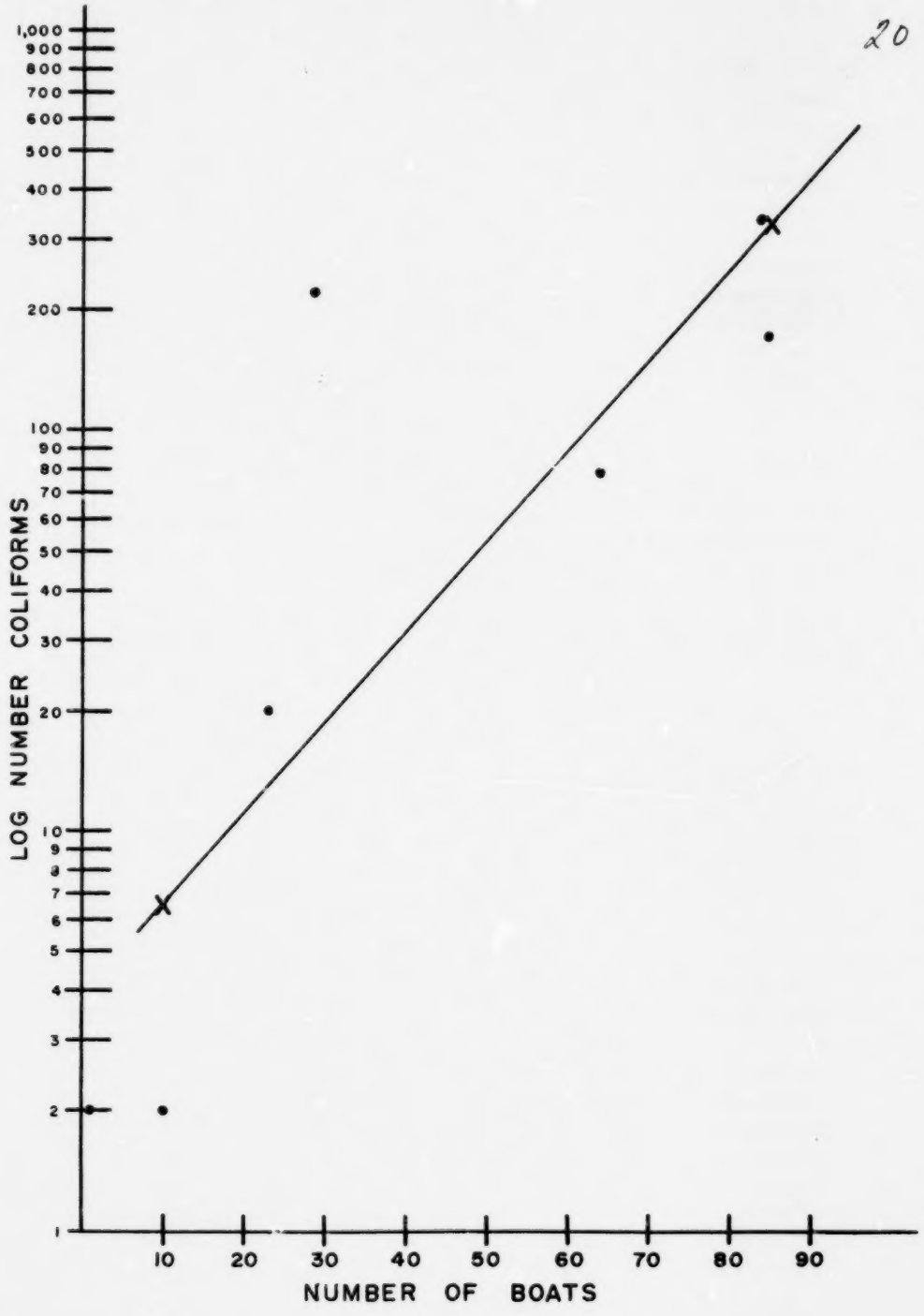
COLIFORM POPULATIONS AND NUMBER OF BOATS
STATION D

FIGURE 5



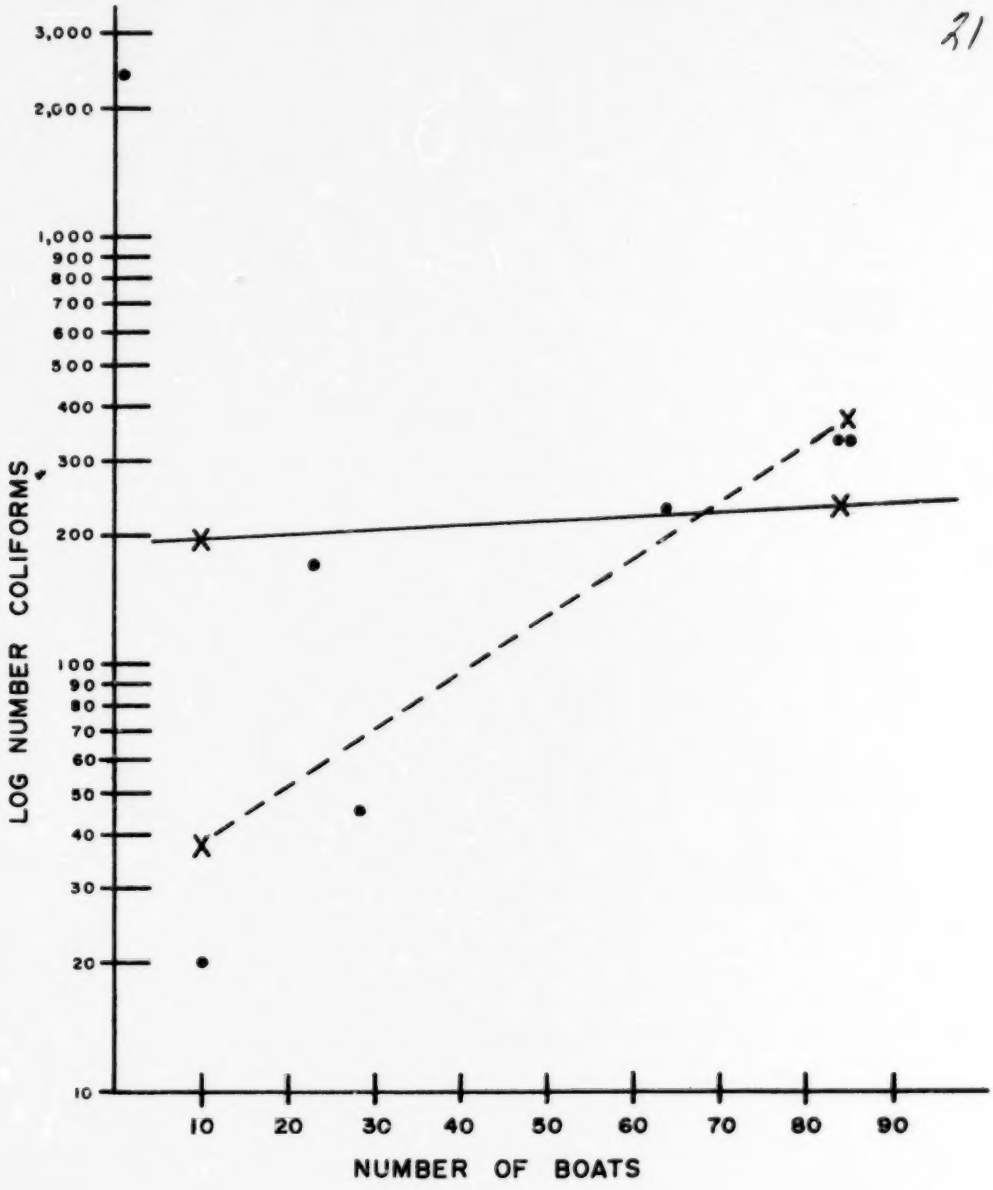
REGRESSION OF INCREMENTS OF BOATS AND COLIFORMS
STATION A

FIGURE 6



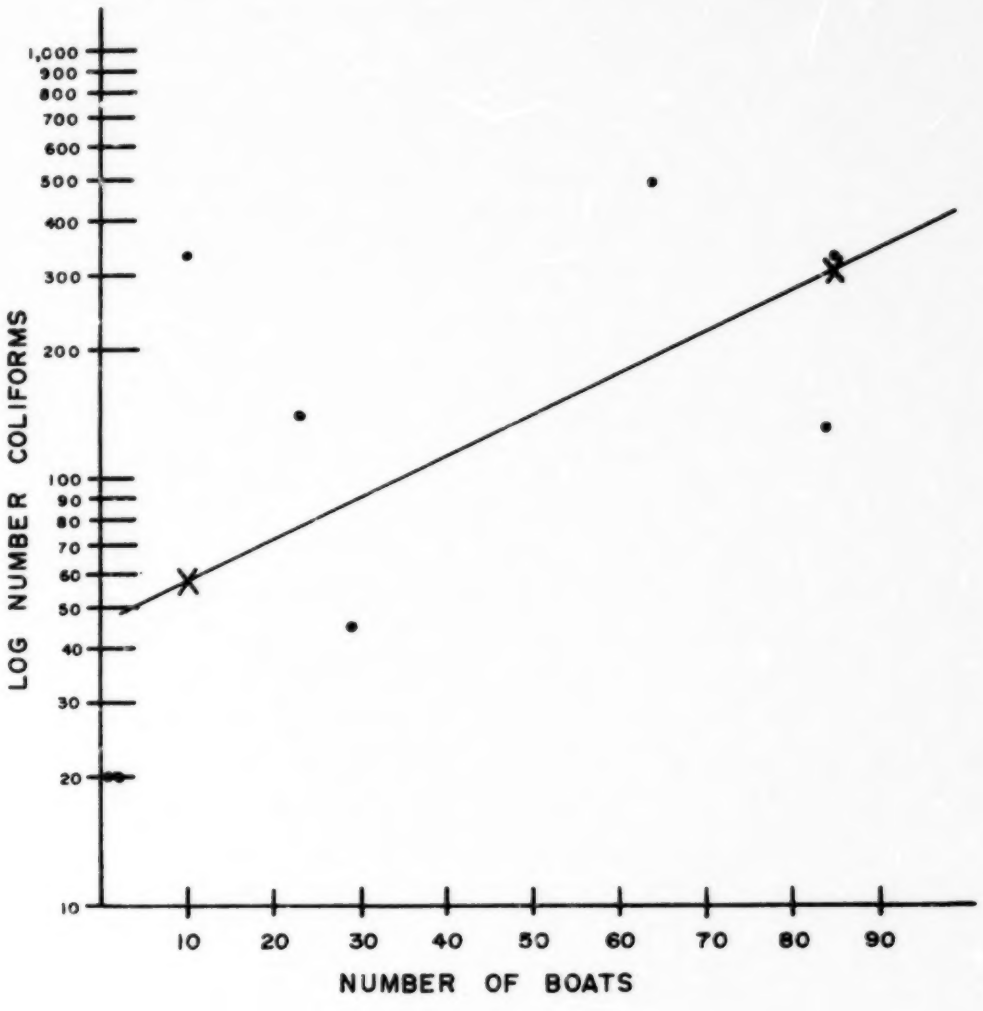
REGRESSION OF INCREMENTS OF BOATS AND COLIFORMS
STATION B

FIGURE 7



REGRESSION OF INCREMENTS OF BOATS AND COLIFORMS
STATION C

FIGURE 8



REGRESSION OF INCREMENTS OF BOATS AND COLIFORMS
STATION D

FIGURE 9